SOME OBSERVATIONS ON THE ECOLOGY AND PHYTOCHEMISTRY OF NICKEL-ACCUMULATING *ALYSSUM* SPECIES FROM THE IBERIAN PENINSULA

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SUGIRTHAMANI SHAW née ARUNASALAM

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ABSTRACT

Experiments were carried out on the tolerance to, and uptake of nickel by Iberian subspecies of A. serpyllifolium. Two of these subspecies, the serpentinic-endemics s.sp. lusitanicum (from Bragança, Portugal) and s.sp. malacitanum (from Málaga, Spain) were hyperaccumulators (>1,000 μg/g in dried leaves) of nickel. Their precursor, s.sp. serpyllifolium (from Granada, Spain) was a non-accumulator of this element.

Seeds of the two serpentine-endemics germinated extensively in nickel concentrations up to 12,000 μg/g (1.2%) whereas s.sp. serpyllifolium only germinated in nickel concentrations of up to 60 μg/ml.

Tolerance tests involving measurement of new root lengths of excised seedlings placed in varying nickel concentrations again showed much greater tolerance of the two serpentinophytes. In both series of experiments, the order of tolerance was: s.sp. lusitanicum > s.sp. malacitanum > s.sp. serpyllifolium.

In pot trials involving seedlings of s.sp. malacitanum grown in mixtures containing varying amounts of calcium, magnesium and nickel, the most important findings were that nickel uptake is somewhat stimulated by an excess of calcium in the substrate. This relationship was confirmed by inter-species and intra-species analyses of naturally-occurring plants. Enhanced calcium uptake concomitant with nickel uptake by hyperaccumulators results in a higher (more favourable) Ca/Mg ratio and thereby counteracts one of the unfavourable edaphic effects of serpentine soils.

The form of nickel in leaves of the three Iberian subspecies was investigated. Nickel existed mainly as a water-soluble polar complex in the vacuoles. Small concentrations of nickel did however exist in cell fractions, particularly in the mitochondria where enzyme systems are located. GLC studies on the purified nickel complexes showed that this element is associated principally with

malic and malonic acids which are present in high concentrations in the hyperaccumulators but not in s.sp. serpyllifolium.

It is suggested that production of malic acid is a mechanism whereby hyperaccumulators can tolerate unfavourable edaphic factors such as nickel-rich soils. Presence of nickel in the mitochondria blocks the citric acid cycle by deactivating malic dehydrogenase leading to build-up of malic acid in the vacuoles which then absorbs excess nickel by a complexing reaction and leads to its diffusion back into the vacuoles from the mitochondria, hence unblocking the citric acid cycle. Malonic acid also blocks the cycle and leads to a reduced level of malic acid and hence lesser tolerance to nickel. This is shown to be the case for s.sp. malacitanum which contains more malonic acid than s.sp. lusitanicum and is also less tolerant to nickel. It is postulated that the chemical evidence suggests that s.sp. lusitanicum and s.sp. malacitanum are sufficiently different chemically to lend weight to the argument that the latter should be promoted to full specific rank as has already been done for s.sp. lusitanicum.

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TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

Page

LIST OF PLATES

A typical _Alyssum_ hyperaccumulator of nickel (_A. robertiannum_ Bern. ex. gren.) from section Ordontarrhena.